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VERIFIED TRANSLATION OF PRIORITY DOCUMENT

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[NAME OF THE DOCUMENT] SPECIFICATION

[THE TITLE OF THE INVENTION]

PRESSURE-SENSITIVE RESISTOR AND PRESSURE-SENSITIVE SENSOR

[CLAIMS]

1. A pressure-sensitive resistor of a pressure-sensitive sensor that includes a pair of electrodes between a first base film and a second base film, a one layer of a pressure-sensitive resistor that is provided through a predetermined gap with at least one of the pair of electrodes, or two layers of pressure-sensitive resistors provided on the pair of electrodes through a predetermined gap therebetween, wherein a contact state between the one layer of the pressure-sensitive resistor and one of the electrodes or a contact state between the two layers of the pressure-sensitive resistors is changed in accordance with a pressure applied through the first base film or the second base film so that a resistance between the pair of the electrodes changes, wherein the pressure-sensitive resistor is characterized in that:

the pressure-sensitive resistor is constructed with electrical conductive particles coated with a polymer, and a binder resin having an elasticity modulus in a range between 10 and 1000 Mpa.

2. The pressure-sensitive resistor according to claim 1, wherein the electrical conductive particles are carbon black particles.

3. The pressure-sensitive resistor according to claim 1 or claim 2, wherein the electrical conductive particles have a

primary particle diameter that is in a range between 8 nm and 300 nm.

4. The pressure-sensitive resistor according to any one of claims 1 - 3, wherein an amount of the polymer coated on the electrical conductive particles is in a range between 1 wt% and 70 wt% with respect to a total amount of the electrical conductive particles and the binder resin.

5. A pressure-sensitive sensor that includes a pair of electrodes between a first base film and a second base film, a one layer of a pressure-sensitive resistor that is provided through a predetermined gap with at least one of the pair of electrodes, or two layers of pressure-sensitive resistors provided on the pair of electrodes through a predetermined gap therebetween, wherein a contact state between the one layer of the pressure-sensitive resistor and one of the electrodes or a contact state between the two layers of the pressure-sensitive resistors is changed in accordance with a pressure applied through the first base film or the second base film so that a resistance between the pair of the electrodes changes, wherein the pressure-sensitive sensor is characterized in that:

the pressure-sensitive resistor is constructed with electrical conductive particles coated with a polymer, and a binder resin having an elasticity modulus in a range between 10 and 1000 Mpa.

[DETAIL DSCRIPTION OF THE PRESENT INVENTION]

[FIELD OF THE INVENTION]

The present invention relates to a pressure-sensitive

resistor and a pressure-sensitive sensor having the pressure-sensitive resistor.

[BACKGROUND OF THE INVENTION]

As a pressure-sensitive sensor have been hitherto known a sensor using volume resistance variation in a resistor when pressure is applied to the resistor ("SENSOR TECHNIQUE", Vol. 19, No. 9, 1989) and a sensor using contact resistance variation at the surface between electrical contact points. In the case of the former sensor, a great deal of pressure must be applied to the sensor to achieve a large resistance variation rate and thus it is generally unsuitable to detect low pressure. Therefore, the applicants of this application has proposed a pressure-sensitive sensor using the contact resistance variation like the latter sensor as in Japanese Patent Application No. Hei. 13-302155.

This pressure-sensitive sensor has a pair of electrodes and two layers of pressure-sensitive resistance materials which are formed on the respective electrodes of the pair of electrodes through a predetermined gap, the pair of electrodes and the two layers being equipped between a pair of base films. The surface of each electrical conductive particle constituting the pressure-sensitive resistant material is coated by extremely thin polymer. When pressure is applied to the base films, the contact area between the pressure-sensitive resistant materials is varied in accordance with the applied pressure, and this variation of the contact area causes variation in true contact area resistance (concentrated

resistance) between the electrodes. The true contact area resistance is based on the contact area, and the resistance variation is little observed when the contact area is saturated.

When the pressure-sensitive resistant materials are deformed by the applied pressure under the state that the pressure-sensitive resistant materials come into contact with each other, the distance between the polymer-coated electrical conductive particles at the contact state between the pressure-sensitive resistance materials is varied, so that the tunnel conduction between the electrical conductive particles is varied and it appears as coating film resistance variation. This pressure-sensitive sensor achieves linear resistance variation in a broad pressure range by using both the resistance variations described above.

[PROBLEMS TO BE SOLVED IN THE PRESENT INVENTION]

However, when pressure of 1 to 20kPa for detection of a passenger in a vehicle or measurement of a body pressure distribution of a human body is mainly set as a detection range, there may occur such a case that even when an applied pressure is increased, the contact area between the pressure-sensitive resistant materials is not increased because the applied voltage is low. In this case, no true contact area resistance variation occurs, and thus no linear resistance variation can be achieved in the above pressure range.

The present invention has been implemented in view of the foregoing problem, and has an object to provide a pressure-

sensitive resistor which can detect the pressure in the range of 1 to 20kPa with a high sensitivity, and a pressure-sensitive sensor having the pressure-sensitive resistor.

[MEANS TO SOLVING THE PROBLEMS]

To achieve the above-described object of the present invention, in a pressure-sensitive resistor of a pressure-sensitive sensor described in claim 1, there is provided with a pair of electrodes between a first base film and a second base film, a one layer of a pressure-sensitive resistor that is provided through a predetermined gap with at least one of the pair of electrodes, or two layers of pressure-sensitive resistors provided on the pair of electrodes through a predetermined gap therebetween. Here, a contact state between the one layer of the pressure-sensitive resistor and one of the electrodes or a contact state between the two layers of the pressure-sensitive resistors is changed in accordance with a pressure applied through the first base film or the second base film so that a resistance between the pair of the electrodes changes. Furthermore, the pressure-sensitive resistor is constructed with electrical conductive particles coated with a polymer, and a binder resin having an elasticity modulus in a range between 10 and 1000 Mpa.

In a case where the pressure-sensitive resistor is used for detecting a low pressure in the range from 1 to 20kPa is applied, if the elastic modulus of the binder resin that is a construction material of the pressure-sensitive resistor is less than 10MPa, the binder resin is easily deformed with

slight pressure, and thus the contact area is saturated at the lower pressure side of the pressure range. Accordingly, when the pressure is further increased, the resistance variation is hardly observed because the true contact area resistance is saturated.

The binder resin is hardly deformed under the pressure at the lower pressure side of the pressure range if the elastic modulus of the binder resin is larger than 1000MPa, and thus the contact area between the pressure-sensitive resistors is very small. Accordingly, the resistance value based on the true contact area resistance exceeds the detectable range ($10^6\Omega$).

Furthermore, when the surfaces of the electrical conductive particles are not coated by a very thin polymer, the contact state between the electrical conductive particles is not largely changed even if the pressure is high or low within the pressure range of 1-20 kPa. Therefore, the coating film resistance becomes extremely small.

The pressure-sensitive resistor according to this embodiment uses binder resin having an elasticity modulus ranging from 10 to 1000Mpa, and electrical conductive particles each of which is coated with polymer. Accordingly, the true contact area resistance variation and the coating film resistance variation which correspond to the pressure occur in the pressure range of 1 to 20kPa. Therefore, the pressure-resistance characteristic of the pressure-sensitive resistor is continuously reduced as the pressure increases,

and the resistance variation rate thereof is large in the resistance-detectable range ($10^6\Omega$ or less). That is, the pressure-sensitive resistor of the present invention can detect the pressure in the range from 1 to 20kPa with high sensitivity.

As described in claim 2, preferably, the electrical conductive particles are carbon black particles. The carbon black particles have a structure construction and a functional group such as a carboxyl group, a hydroxyl group or the like on the surface and is liable to be coated with polymer.

As described in claim 3, the electrical conductive particles have a primary particle diameter that is in a range between 8 nm and 300 nm. If the primary particle diameter is smaller or larger than this range, it is difficult to uniformly coat the surfaces of the electrical conductive particles with the polymer.

As described in claim 4, an amount of the polymer coated on the electrical conductive particles is in a range between 1 wt% and 70 wt% with respect to a total amount of the electrical conductive particles and the binder resin. If the coated amount is smaller than thin range, the coating effect becomes smaller, and the resistance change rate of the pressure-sensitive resistance becomes smaller. Further, if the coated amount is larger than thin range, the resistance value of the pressure-sensitive resistance becomes smaller at a low pressure side, and is difficult to be detected.

The pressure-sensitive sensor described in claim 5 uses

the pressure-sensitive resistor described in claim 1, and the operation effects are similar to those of claim 1. Therefore, the explanation is omitted.

[EMBODIMENTS OF THE PRESENT INVENTION]

The first embodiment of the present invention will be described hereinafter based on the drawings.

(First Embodiment)

A pressure-sensitive sensor in which a pressure-sensitive resistor in this embodiment is formed will be explained using Figs. 1 and 2. Fig. 1 is a cross-sectional view showing a schematic structure of the pressure-sensitive sensor, and Fig. 2 is a partial plan view of the pressure-sensitive resistor. In this embodiment, a pressure-sensitive resistor and a pressure-sensitive sensor are used to detect a passenger in a vehicle, measure a body pressure distribution of a human on a bed or the like, and also it is used to detect low pressure (1 to 20kPa) with high precision.

As shown in Fig. 1, the pressure-sensitive sensor 1 comprises first and second base films 2 serving as base materials, a pair of electrodes 3 formed on the respective base films 2, pressure-sensitive resistors 4 formed on the respective electrodes 3 and spacers 6 for providing a predetermined gap 5 between the pressure-sensitive resistors 4. In this embodiment, a pressure-sensitive sensor having a double-sided structure achieved by forming an electrode 3 and a pressure-sensitive resistor 4 formed on each of two base films 2 and then confronting these two base faces through a

predetermined gap 5 will be described as the pressure-sensitive sensor 1. The pressure-sensitive resistor 4 of Fig. 1 may be equipped on only one electrode 3. Furthermore, the pressure-sensitive sensor may be designed to have a shorting bar structure that a pair of electrodes 3 are formed on one base film 2 to be spaced from each other at a predetermined interval and a pressure-sensitive resistor 4 is formed on the other base film 2.

The base film 2 may be formed of polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polyether imide (PEI), polyphenylene sulfide (PPS) or other general resin film.

The electrode 3 is achieved as follows. That is, metal particles of Cu, Ag, Sn or the like is added with solvent, and kneaded to achieve paste or ink. Thereafter, the paste or ink thus achieved is subjected to pattern formation on the base film 2 by a screen printing method or an ink jetting method and dried. As shown in Fig. 2, a lead 3a to be connected to the external together with the electrode 3 is formed. Fig. 2 is a plan view of the pressure-sensitive sensor 1 of Fig. 1 which is viewed in the direction from the gap 5 to the base film 2. For convenience sake of description, a part of the electrode 3 as the lower layer of the pressure-sensitive resistor 4 is illustrated as being seen through the pressure-sensitive resistor 4.

The pressure-sensitive resistor 4 contains electrical conductive particles and binder resin as the constituent

material. The constituent material is added with organic solvent and kneaded to achieve paste or ink, and the paste or ink thus achieved is pattern-formed so as to cover the surface of the electrode 3 by the screen printing method or the ink jetting method, and then dried. At this time, the paste or ink is adjusted to that the pressure-sensitive resistor 4 exhibits a linear pressure-resistance characteristic in the pressure range from 1 to 20kPa and the resistance variation rate (pressure sensitivity) is increased in the resistance-detectable range.

The electrical conductive particles may be formed of metal particles of Ag, Cu or alloy thereof, semiconductor oxide such as SnO_2 or the like, carbon black or the like. It is preferable to use carbon black which has a structure construction and a functional group such as a carboxyl group, a hydroxyl group or the like on the surface and is liable to be coated with polymer. This embodiment uses carbon black. Polymer is coated on the surface of each electrical conductive particle. The effect is described later.

Furthermore, the primary particle diameter (average particle diameter) of the electrical conductive particles is preferably set in the range from 8nm to 300nm. More preferably, it is set in the range from 15nm to 100nm. In this case, polymer can be uniformly coated on the surface of each electrical conductive particle.

The polymer is preferably formed of thermosetting resin such as phenol resin, urea resin, melamine resin, xylene resin,

diallyl phthalate resin, epoxy resin, urethane resin, benzoguanamine resin or the like. The materials may be used alone or two or more kinds of materials may be mixed and used. Phenol resin, xylene resin and epoxy resin out of these thermosetting resin materials are preferable, and particularly epoxy resin is more preferable because it has excellent heat resistance.

The method of coating the electrical conductive particles with the above polymer is not limited to a specific one. For example, the following method may be used. That is, after the blend amount of the electrical conductive particles and the polymer is properly adjusted, the polymer is mixed with and solved in solvent such as cyclohexanone, toluene, xylene or the like to achieve solution. Furthermore, the electrical conductive particles and water are mixed with each other to achieve slurry. The solution and the slurry thus achieved are mixed and stirred, and then the electrical conductive particles and the water are separated from each other. Thereafter, the resultant is heated and kneaded to achieve a composition, and the composition thus achieved is formed in a sheet shape, pulverized and then dried. Alternatively, there may be used a method of mixing and stirring the solution and the slurry achieved in the same manner as described above to granulate the electrical conductive particles and the polymer, and then separating the composition thus achieved. Furthermore, there may be used a method of providing reactive functional groups to the surface of each electrical conductive particles,

adding polymer to the particles and then dry-blending. Still furthermore, the following method may be used. That is, monomer components having reactive groups constituting polymer and water are stirred at high speed to adjust slurry, polymerized and then cooled to achieve resin having reactive groups from the polymerized slurry. Thereafter, the resultant is added with electrical conductive particles and kneaded to react the electrical conductive particles and the reactive groups, and then the resultant is cooled and pulverized.

As the binder resin may be used a single material or a mixture of two or more materials selected from epoxy resin, polyester resin, phenol resin, amino resin, urethane resin, silicon resin, etc. Preferably, urethane resin is used. In this embodiment, the elastic modulus is set in the range from 10Mpa to 1000Mpa, preferably in the range from 10Mpa to less than 800Mpa. The effect of the binder resin on the pressure-resistance characteristic will be described later.

As the organic solvent may be used a single material or a mixture of two or more materials selected from ketone type solvent such as methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone or the like, aromatic hydrocarbon type solvent such as toluene, xylene, Solvent 100 (produced by Esso Company) or the like, ester type solvent such as ethyl acetate, butyl acetate, cellosolve acetate or the like, ether type solvent such cellosolve, butyl cellosolve, butyl carbitol or the like, alcohol type solvent such as isopropyl alcohol, normal butanol, isobutanol, etc. in consideration of the

compatibility with the binder resin. The addition amount is properly adjusted in accordance with the viscosity of the target paste or ink.

As shown in Fig. 1, the spacers 6 provide and keep a desired gap 5 between the pressure-sensitive resistors 4 when the pair of base films 2 each of which has the electrode 3 and the pressure-sensitive resistor 4 formed on the confronting surface thereof are disposed so that the pressure-sensitive resistors 4 face each other. As the spacers 6 may be used adhesive for print which is formed of acrylic resin or the like, laminate film of thermo-compression agent, PET having adhesive layers on both sides thereof or the like. As shown in Fig. 2, the spacers 6 are designed in a C-shape so as to surround the electrodes 3 and the pressure-sensitive resistors 4 in a larger inner diameter so that the spacers 6 are not overlapped with the electrodes 3 and the pressure-sensitive resistors 4.

In the pressure-sensitive sensor 1 thus constructed, when pressure is applied to the base film 2, the base film 2 is deformed in accordance with the pressure concerned, and the contact state between the pressure-sensitive resistors 4 is varied. Accordingly, the resistance value between the electrodes 3 is varied in accordance with the pressure, and thus the applied pressure can be detected on the basis of the resistance value concerned.

Next, an example of the method of manufacturing the pressure-sensitive resistor 4 will be briefly described.

First, the electrical conductive particles are coated by polymer. The slurry achieved by mixing carbon black as electrical conductive particles (the primary particle diameter thereof is set in the range from 8nm to 300nm, and preferably in the range from 15nm to 100nm) and water is mixed and stirred with epoxy resin solution achieved by mixing and dissolving epoxy resin as polymer in toluene. The carbon black and the epoxy resin are granulated, and the granules thus achieved are separated, thereby achieving carbon black coated by the epoxy resin.

After predetermined amounts of the binder resin and the organic solvent are weighed and mixed with each other. Thereafter, a predetermined amount of carbon black coated by epoxy resin is added to the mixture solution, and well blended and dispersed by three-roll mills or the like. In the pressure range of 1 to 20kPa, the thickness of the polymer coating on the electrical conductive particles is set to a value from not less than 10nm to not more than 20nm in order to increase the resistance variation rate (pressure sensitivity) of the pressure-resistance characteristic of the pressure-sensitive resistor 4 in the detectable range of the resistance value. At this time, in order to implement the above polymer thickness, the addition amounts of the electrical conductive particles and the binder resin are determined so that the amount of the polymer coated on the electrical conductive particles is set in the range from 1wt% to 70wt% with respect to the total amount of the electrical conductive particles and the binder

resin. At this time, in order to achieve a larger tunnel conduction effect, the addition amounts of the electrical conductive particles and the binder resin are determined so that the amount of the polymer is set in the range from 1wt% to 50wt%.

After the blend/dispersion, resistant paste having a predetermined viscosity is achieved by using a kneading machine such as a stone mill or the like, and it is pattern-printed by the screen printing method so as to have a WET film thickness of several μm to several tens μm and cover the surface of the electrode 3 formed on the base film 2. The resistant paste thus printed is held and dried at a temperature of 50 to 200°C for 0.5 to 3h, thereby forming the pressure-sensitive sensor 1 having the pressure-sensitive resistor 4. When thermosetting resin is used, a batch type furnace, a belt furnace, a far infrared radiation furnace or the like is used and the thermosetting resin is cured simultaneously with drying of the resistant paste.

Here, the effect on the pressure-resistance characteristic by the coating of polymer on electrical conductive particles and the effect of the elastic modulus of the binder resin will be described with reference to Figs. 3(a) and 3(b). Fig. 3(a) is a supplemental figure to describe the effect of the elastic modulus of the binder resin, and Fig. 3(b) is a supplemental figure to describe the effect of the polymer coating.

In the pressure-sensitive sensor 1 having the pressure-

sensitive resistor 4, when pressure is applied to the base film 2, the base film 2 is deformed and also the electrode 3 and the pressure-sensitive resistor 4 formed on the surface of the base film 2 are deformed. At this time, the confronting pressure-sensitive resistors 4 start to partially come into contact with each other, and the true contact area resistance (concentrated resistance) is dominantly varied upon the application of the pressure at the initial stage of the contact. When pressure is further applied, the pressure-sensitive resistor 4 is deformed, and the contact area of the upper and lower pressure-sensitive resistor 4 is increased, so that the true contact area resistance is reduced. At this time, by the deformation of the pressure-sensitive resistor 4, the contact pressure is applied to the electrical conductive particles coated with polymer at the contact site on the surface of the pressure-sensitive resistor 4, and the distance between the electrical conductive particles is reduced, so that the tunnel conduction between the electrical conductive particles is intensified, and the coating resistance is reduced.

As described above, the pressure-sensitive sensor 1 according to this embodiment detects the applied pressure on the basis of the variation of the value (surface contact resistance) achieved by adding the true contact area resistance (or the concentrated resistance) caused by the contact area between the actual pressure-sensitive resistors 4 with the coating resistance of the electrical conductive

particles between the surfaces of the contacted pressure-sensitive resistors 4.

Viewing the surface of the pressure-sensitive resistor 4 microscopically, it has an uneven shape as shown in Fig. 3(a). When pressure is applied, the contact occurs at an uneven portion 10 at which the distance between the pressure-sensitive resistors 4 is shortest. Here, when pressure in the range from 1 to 20kPa is applied, the binder resin would be hardly deformed under the pressure at the lower pressure side of the pressure range described above if the elastic modulus of the binder resin is larger than 1000MPa, and thus the contact area is very small. Accordingly, the resistance value based on the true contact area resistance exceeds the detectable range ($10^6\Omega$).

Furthermore, if the elastic modulus of the binder resin is less than 10MPa, the binder resin is easily deformed with slight pressure, and thus the contact area is saturated at the lower pressure side of the pressure range described above. Accordingly, when the pressure is further increased, the resistance variation is hardly observed because the true contact area resistance is saturated.

The pressure-sensitive resistor 4 and the pressure-sensitive sensor 1 according to this embodiment uses the binder resin whose elastic modulus ranges from not less than 10MPa to not more than 1000MPa. Accordingly, when the pressure in the range from 1 to 20kPa is applied, the resistance value based on a proper true contact area initially exists under

pressure at the low pressure side of the range, and the contact area between the pressure-sensitive resistors 4 is not saturated and the resistance value is varied in accordance with the pressure at the high pressure side, so that the resistance value can be varied in accordance with the applied pressure.

The surfaces of the electrical conductive particles of the pressure-sensitive resistors 4 of this embodiment are coated by polymer. Accordingly, as shown in Fig. 3(b), when the pressure applied in the range from 1 to 20kPa is increased, the contact pressure is applied to the electrical conductive particles 12 coated by the polymer 11 on the surfaces of the pressure-sensitive resistors 4 which come into contact with each other, so that the tunnel conduction between the two electrical conductive particles 12 is intensified and also the coating resistance is reduced. Accordingly, by the variation of the coating resistance as described above, the resistance variation rate can be increased in the resistance-value detectable range of the pressure range from 1 to 20kPa by adding the true contact area resistance with the coating resistance in the pressure-sensitive resistors 4 of this embodiment.

The pressure-sensitive resistor 4 and the pressure-sensitive sensor 1 having the pressure-sensitive resistors 4 according to this embodiment have the polymer 11 on the surface of each electrical conductive particle 12, and the elastic modulus of the binder resin is set to a value in the

range from not less than 10MPa to not more than 1000MPa, so that the pressure in the range from 1 to 20kPa can be detected with high sensitivity.

It is more preferable that the elastic modulus of the binder resin ranges from not less than 10MPa to less than 800MPa. When the elastic modulus is set in the range from not less than 800MPa to not more than 1000MPa, the uneven portion 10 of the pressure-sensitive resistor 4 is hardly deformed and the effect of the coating resistance variation is hardly achieved particularly at the low pressure side at which the applied pressure is equal to 1 to 20kPa. Accordingly, if the elastic modulus of the binder resin ranges from not less than 10MPa to less than 800MPa, the effect of the coating resistance variation can be achieved from the lower pressure side, and the pressure-resistance characteristic in the range from 1 to 20kPa can be made smoother.

Here, the resistance value variation in the pressure range from 1 to 20kPa was checked in the pressure-sensitive sensor 1 having the pressure-sensitive resistor 4 formed according to this embodiment. Figs. 4(a), 4(b) and 5 show the results of the embodiment. Fig. 4 is a graph showing the pressure-resistance characteristic in accordance with the presence or absence of polymer, Fig. 4(a) shows a case where the elastic modulus of the binder resin is equal to 1000MPa, and Fig. 4(b) shows a case where the elastic modulus of the binder resin is equal to 200MPa. Fig. 5 is a graph showing the pressure-resistance in accordance with the elastic modulus of

the binder resin.

As the binder resin was used urethane resin having an elastic modulus of 1000MPa as Example 1, urethane resin having an elastic modulus of 200MPa as Example 2 and urethane resin having an elastic modulus of 10MPa as Example 3. As the electrical conductive particles 12 were used carbon black (MAB produced by Mitsubishi Chemicals Co., Ltd.) coated with epoxy resin (Epicoat produced by Japan Epoxy Resin Co., Ltd.) in which the primary particle diameter is equal to 24nm and the structure (DBP absorption amount) is equal to about 60ml/100g. The blend ratio of the carbon black (containing polymer coating) and the urethane resin was set to 47.5 : 52.5, and the amount of the polymer coating was set to 10wt% of the total amount of the carbon black and the epoxy resin. Then, the pressure-sensitive sensor 1 having the pressure-sensitive resistor 4 was manufactured according to the manufacturing method of this embodiment, and the resistance value was measured while pressure in the range from 1 to 20kPa was applied.

In the pressure-sensitive sensors 1 of the first to third embodiments, PET of 75μm in thickness was used as the base film 2, and Ag was used as the electrode 3. Furthermore, polyester type resin of 40μm in thickness was attached as the spacer 6 between the confronting surfaces of a pair of base films 2, and the ratio (aspect ratio) of the diameter of the upper and lower surfaces of the gap 5 to the thickness (in the laminate direction) of the gap was set to 300.

As Comparison Examples of Examples 1 and 2, pressure-sensitive sensors 1 were manufactured by using carbon black coated with no epoxy resin, and the measurement results of the sensors 1 concerned are shown as Comparison Examples 1 and 2.

As shown in Figs. 4(a) and 4(b), it is apparent that the resistance variation rate is increased within the resistance-detectable range in the pressure-sensitive sensors 1 of Examples 1 and 2 as compared with the Comparison Examples 1 and 2 using the electrical conductive particles 12 having no polymer coating. However, in the case of Example 1, the elastic modulus of the binder resin is equal to 1000MPa, and the pressure-sensitive resistor 4 is hardly deformed under low pressure, and thus the effect of the coating resistance variation by the polymer coating is reduced in the low pressure area as shown in Fig. 4(a). On the other hand, in the case of Example 2, the effect of the coating resistance variation is also observed in the low pressure area as shown in Fig. 4(b), and thus this is more preferable.

Subsequently, pressure-sensitive sensors 1 were manufactured by using binder resin having an elastic modulus of 1MPa and 2000MPa, and measurement results achieved by these sensors 1 were set as Comparison Examples 3, 4. In the Comparison Example 3, silicon resin was used as the binder resin in place of urethane resin and the blend ratio between carbon black (containing polymer coating) and silicon resin was set to 15:85. In the Comparison Example 4, polyester resin was used as the binder resin in place of urethane resin, and

the blend ratio between carbon black (containing polymer coating) and polyester resin was set to 15:85.

As shown in Fig. 5, Examples 1 to 3 used the binder resin whose elastic modulus was set in the range from 10 to 1000MPa, and in the pressure range of 1 to 20kPa, these Examples showed a linear resistance variation and a large resistance variation rate in the resistance detectable range. On the other hand, the Comparison Example 3 using the binder resin having an elastic modulus of 1MPa exhibited a smooth resistance variation, and it exhibited little resistance variation when the pressure was equal to 10kPa or more. In the case of the Comparison Example 4 in which the binder resin whose elastic modulus was 2000 MPa was used, the initial resistance value under pressure of about 1kPa exceeded 10^6 Ω, and thus it was difficult to measure the resistance value.

As described above, in the pressure range of 1 to 20kPa, the pressure-sensitive resistor 4 and the pressure-sensitive sensor 1 according to this embodiment can exhibit the linear pressure-resistance characteristic and the large resistance variation rate in the resistance-detectable range. That is, the pressure in the range from 1 to 20kPa can be detected with high sensitivity.

Although the preferred embodiment is explained as described above, the present invention is not limited to the above-described embodiment, and various changes can be made possible.

In this embodiment, when the resistance paste is formed

to achieve the pressure-sensitive resistor, the resistance paste is composed of electrical conductive particles coated with polymer, binder resin and solvent. However, in addition to these elements, dispersant may be added to enhance the dispersibility of the electrical conductive particles coated with the polymer, or spherical filling material or the like may be added to assist the pressure-sensitive characteristic.

The pressure-sensitive resistor 4 and the pressure-sensitive sensor 1 having the pressure-sensitive resistor 4 of the embodiment can detect the pressure in the range from 1 to 20kPa with high sensitivity, and the pressure detecting range (use range) is not limited to the range from 1 to 20kPa.

Furthermore, in the pressure-sensitive sensor 1 of this embodiment, the ratio (aspect ratio) of the diameter of the upper and lower faces of the gap to the thickness (in the laminate direction) of the gap is set to 300. However, the aspect ratio is not limited to 300. Accordingly, the aspect ratio may be determined in combination with the elastic modulus of the binder resin. For example, when the detection is started from a pressure side which is slightly lower than 1kPa, the aspect ratio may be set to a value larger than 300.

[SIMPLE EXPLANATION OF DRAWINGS]

Fig. 1 is a schematic sectional view of a pressure-sensitive sensor according to a first preferred embodiment of the present invention.

Fig. 2 is a partial plan view of the pressure-sensitive sensor.

Fig. 3 is a schematic view for explaining effects of pressure-resistance characteristics, in which Fig. 3(a) shows an elastic modulus of a binder resin, and Fig. 3(b) shows an effect of a polymer coating of electrical conductive particles.

Fig. 4 is a graph showing effects of pressure-resistance characteristics due to the polymer coating, in which Fig. 4(a) is a case where the elastic modulus of binder resin is equal to 1000 Mpa and Fig. 4(b) is a case where the elastic modulus of the binder resin is equal to 200 Mpa.

Fig. 5 is a graph showing pressure-resistance characteristics due to the elastic modulus of the binder resin.

[Explanation of Reference Numbers]

1 . . . Pressure sensor

2 . . . Base film

3 . . . Electrode

4 . . . Pressure-sensitive resistor

5 . . . Gap

6 . . . Spacer

10 . . . Uneven portion

11 . . . Polymer

12 . . . Electrical conductive particles

[NAME OF THE DOCUMENT] ABSTRACT OF THE DISCLOSURE

[ABSTRACT]

[OBJECT]

It is an object of the present invention to provide a pressure-sensitive resistor which can detect a pressure in a range of 1 to 20 kPa with high sensitivity, and a pressure-sensitive sensor having the pressure-sensitive resistor.

[MEANS FOR SOLVING PROBLEMS]

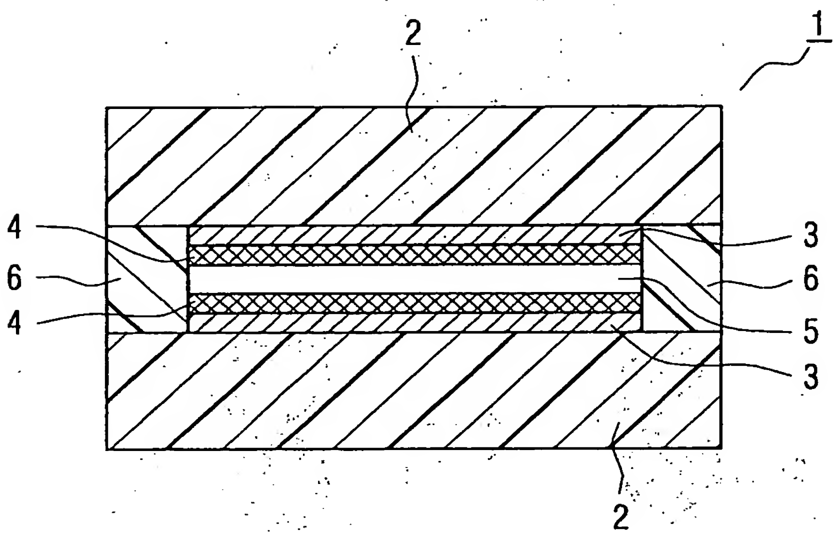
In a pressure-sensitive sensor 1, electrodes 3 and pressure-sensitive resistors 4 are formed on opposite surfaces of a pair of base films 2, and a spacer 6 is arranged between the base films 2 to form a predetermined gap between the pressure-sensitive resistors 4. A contact state between the pressure-sensitive resistors 4 is changed in accordance with a pressure applied through the base films 2, so that a resistance between the electrodes 3 is changed. In addition, each of the pressure-sensitive resistors is constructed with a binder resin having an elasticity modulus in a range between 10 and 1000 Mpa, and electrical conductive particles coated with a polymer.

Accordingly, the pressure-sensitive resistors 4 and the pressure-sensitive sensor 1 can detect a pressure in a range between 1 and 20 kPa with a high sensitivity.

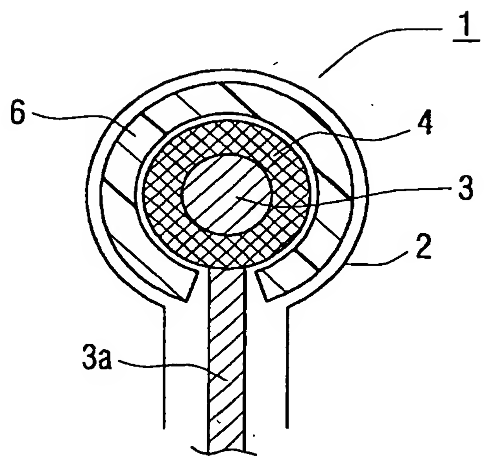
[SELECTED FIGURE] Fig. 3

【書類名】　図面　[DOCUMENTS] DRAWINGS

【図１】　[FIG. 1]

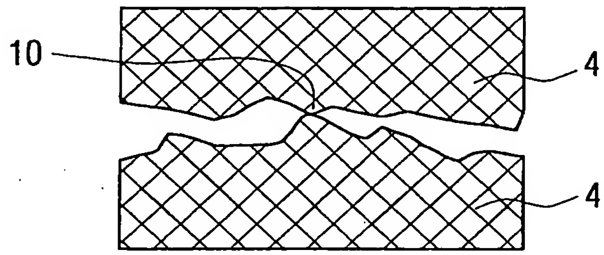


【図２】　[FIG. 2]

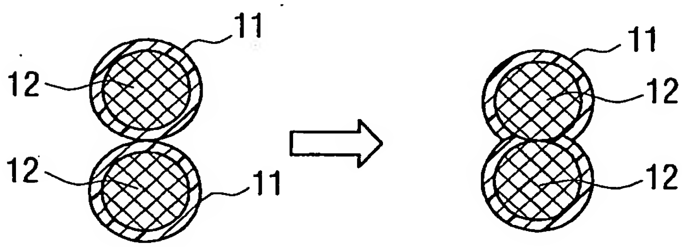


【図３】　[FIG.3]

(a)

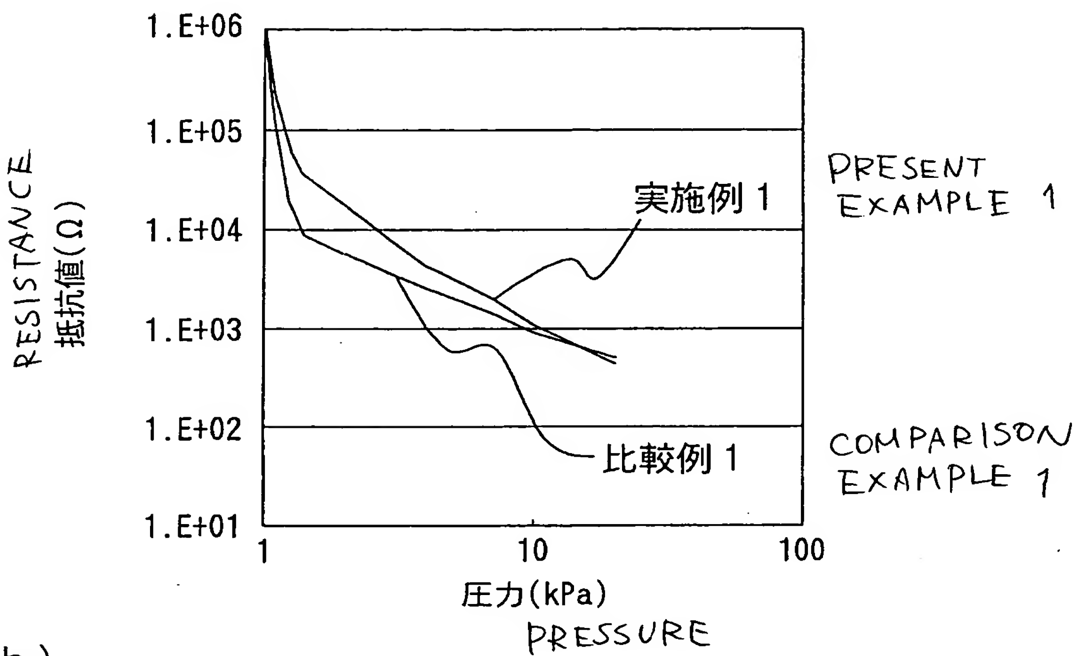


(b)

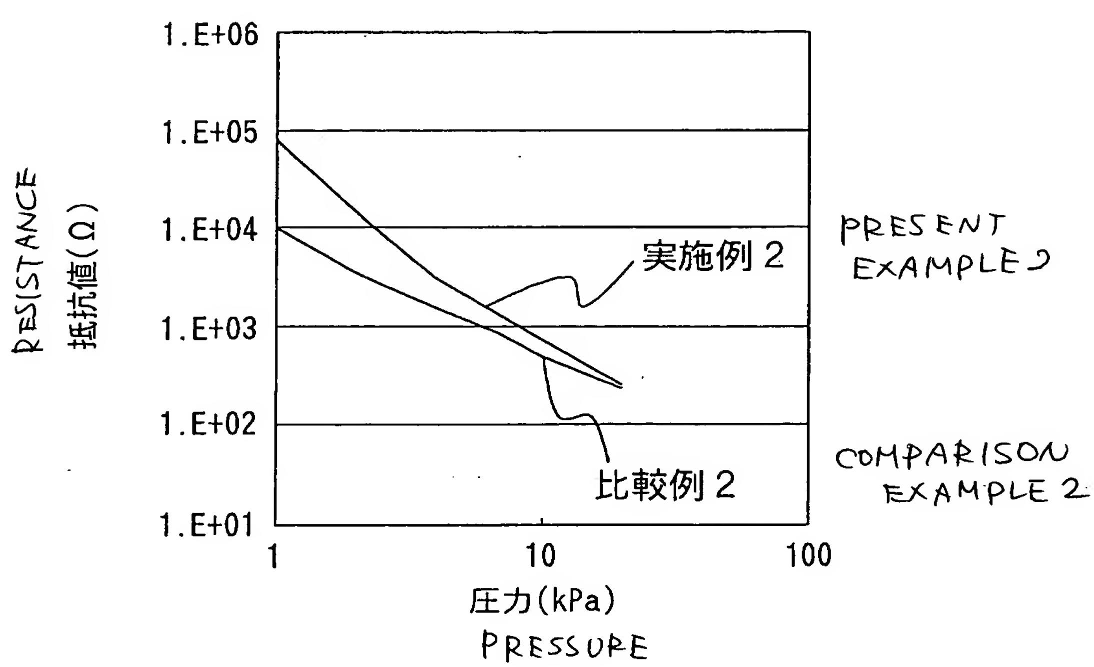


【図４】　[FIG.4]

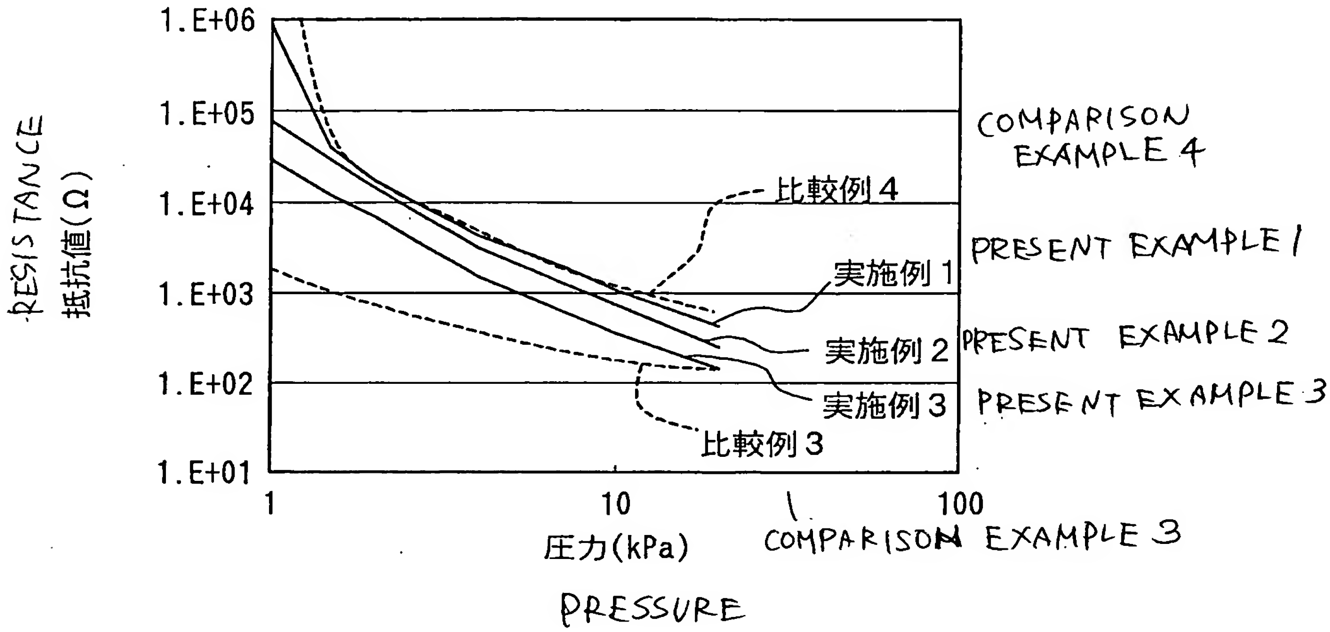
（ａ）


1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
RESISTANCE
抵抗値(Ω)
実施例 1
PRESENT EXAMPLE 1
比較例 1
COMPARISON EXAMPLE 1
1
10
100
圧力(kPa)
PRESSURE

（ｂ）


1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
RESISTANCE
抵抗値(Ω)
実施例 2
PRESENT EXAMPLE 2
比較例 2
COMPARISON EXAMPLE 2
1
10
100
圧力(kPa)
PRESSURE

【図５】


RESISTANCE
抵抗値(Ω)
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1
10
100
圧力(kPa)
PRESSURE
比較例４
COMPARISON EXAMPLE 4
実施例１
PRESENT EXAMPLE 1
実施例２
PRESENT EXAMPLE 2
実施例３
PRESENT EXAMPLE 3
比較例３
COMPARISON EXAMPLE 3